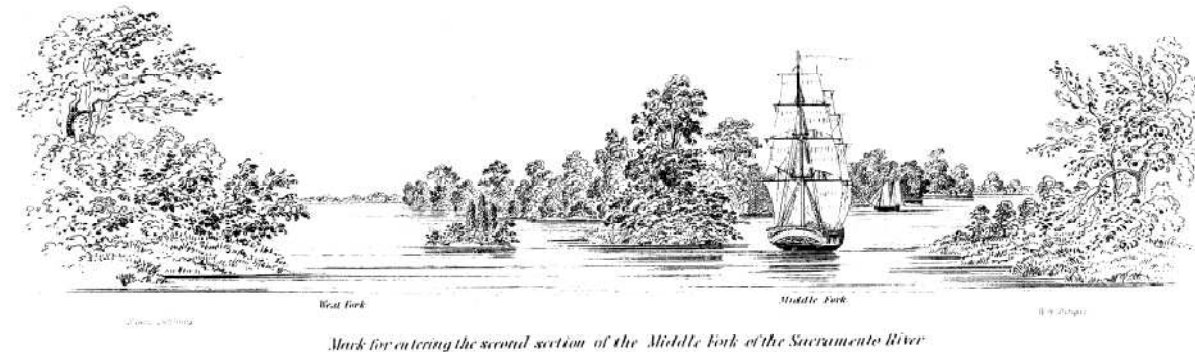
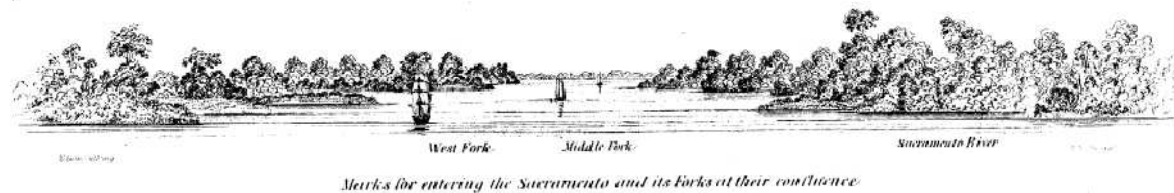
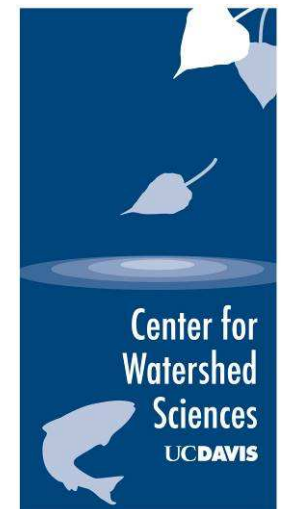


# The Sacramento-San Joaquin Delta: Managing the Inevitable



Jeffrey Mount, Jay Lund, Ellen Hanak, William Fleenor, William Bennett, Richard Howitt, Peter Moyle, Robyn Suddeth

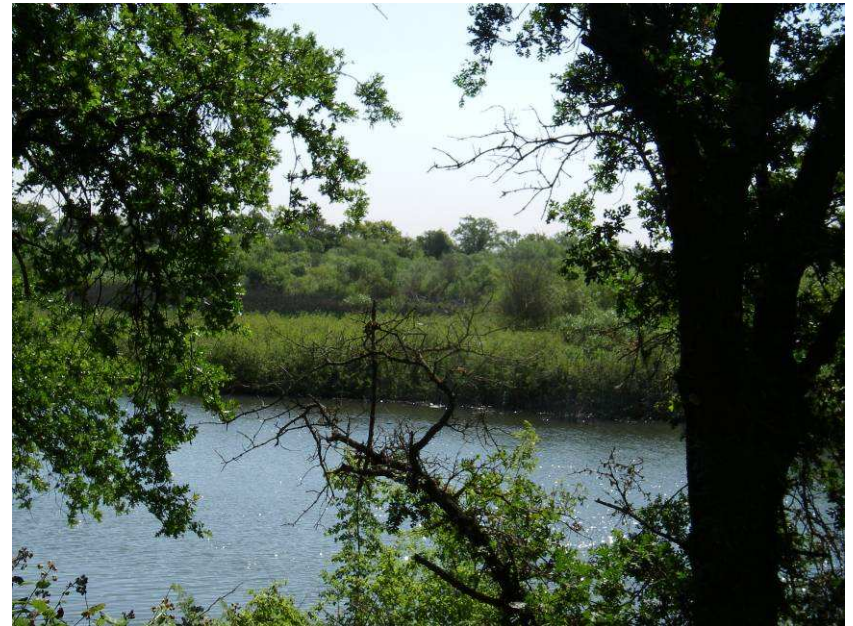


# Delta of the Past



- 700,000 acre tidal marsh
- Mostly fresh water, with brackish water at western end
- A product of Holocene rise in sea level
- Extraordinary organic accumulations
- High hydrologic residence time





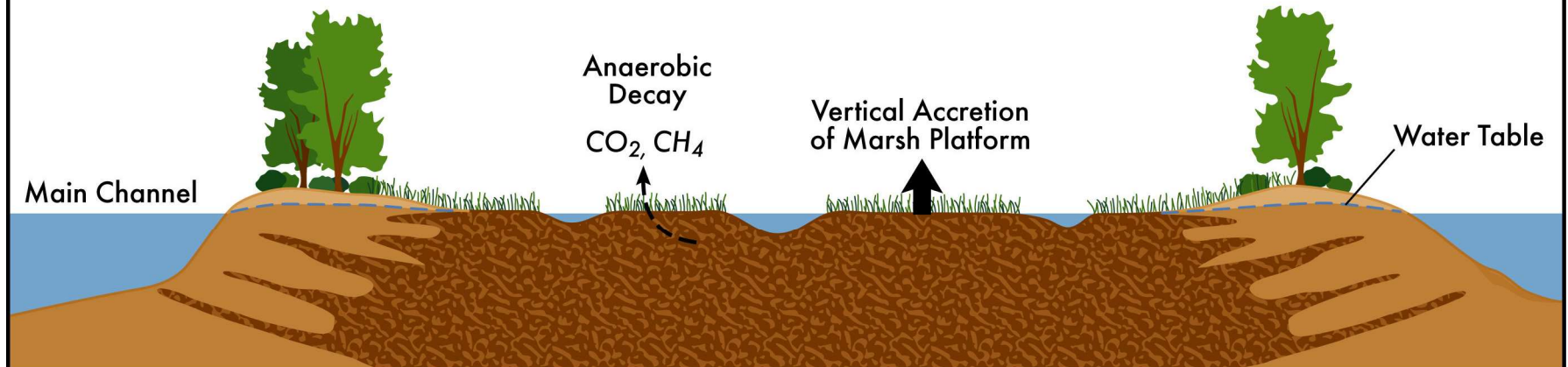
# Transition to the 20<sup>th</sup> Century Delta



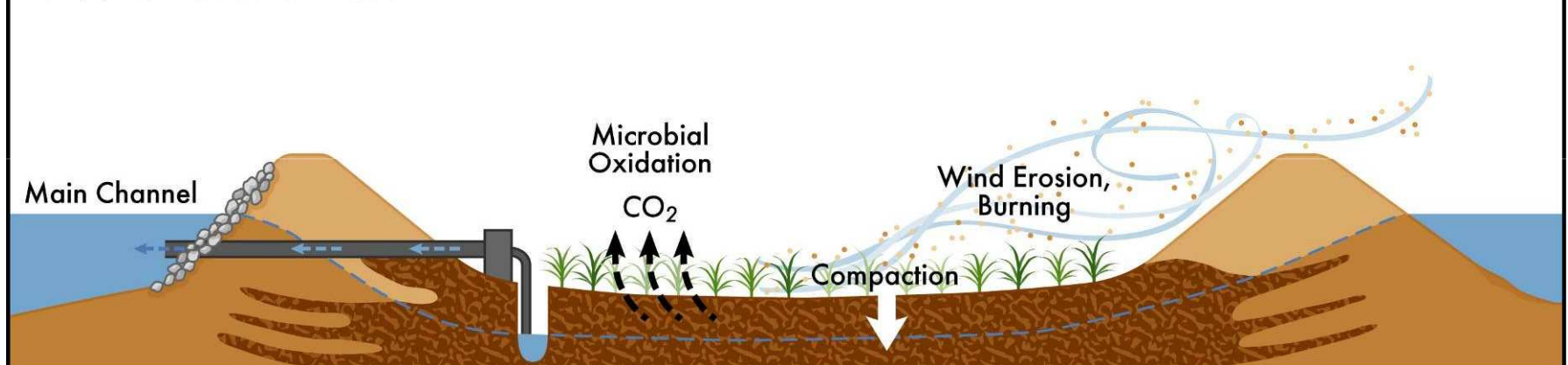
- Reclamation of 700,000 acres of tidal freshwater marsh
- 1100 miles of levees separate land from water (most of the time)
- Reductions in inflows by 50%
- Transition from dynamic, self-adjusting to static, homogeneous Delta



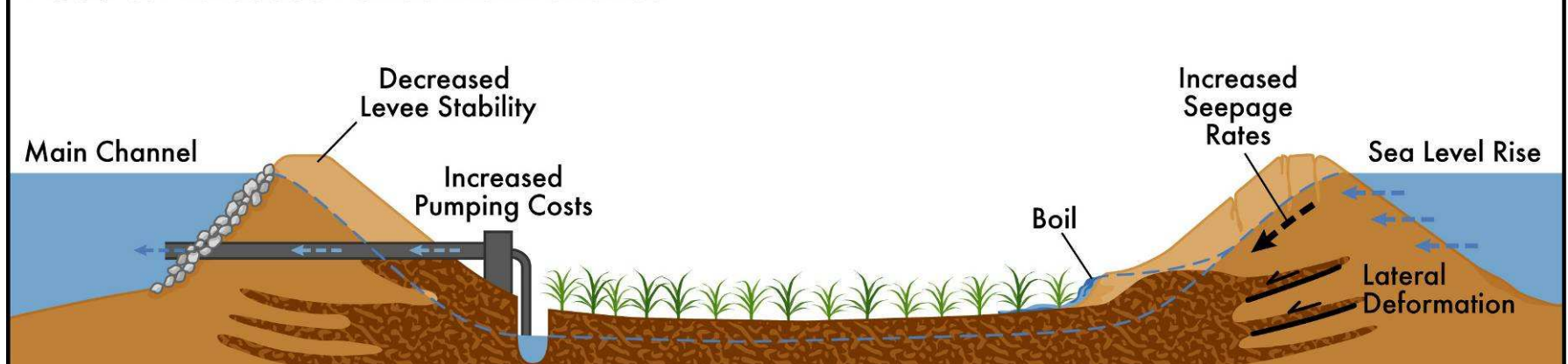
## Pre-1880: Freshwater Tidal Marsh



## 1900's: Elevation Loss



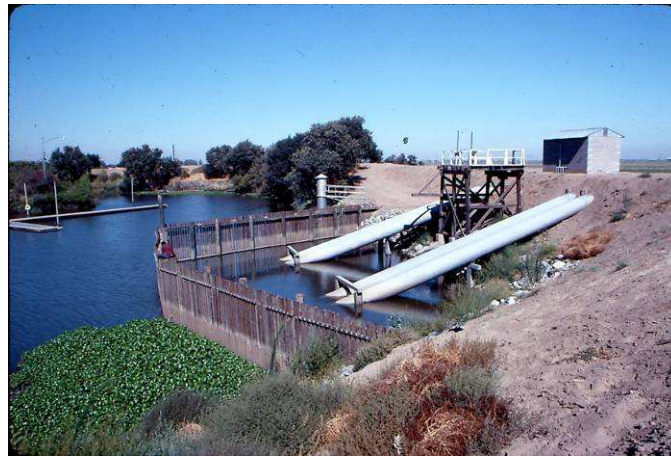
## 2000's: Increased Levee Maintenance



# Water Supply: an Afterthought

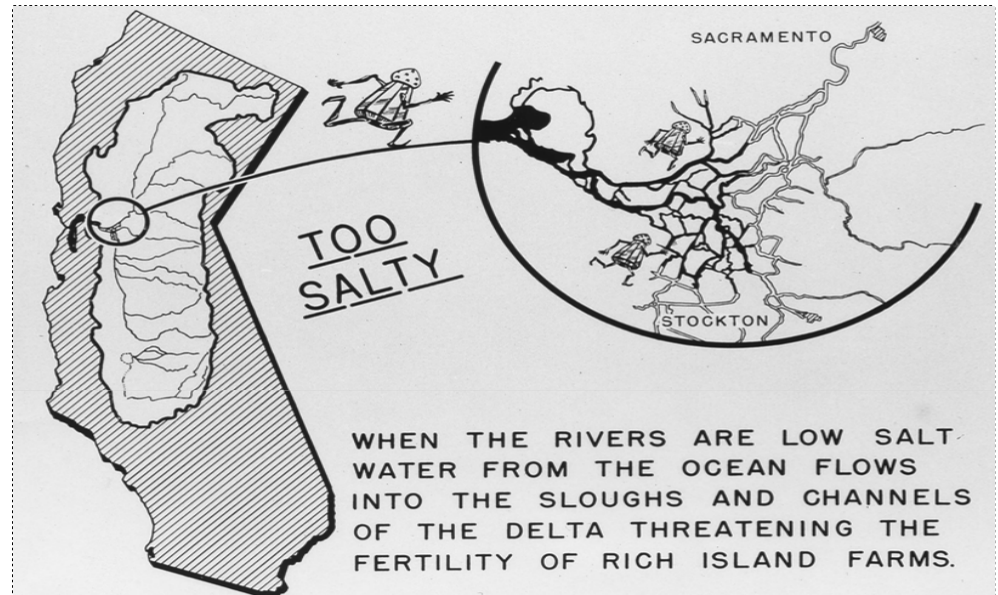
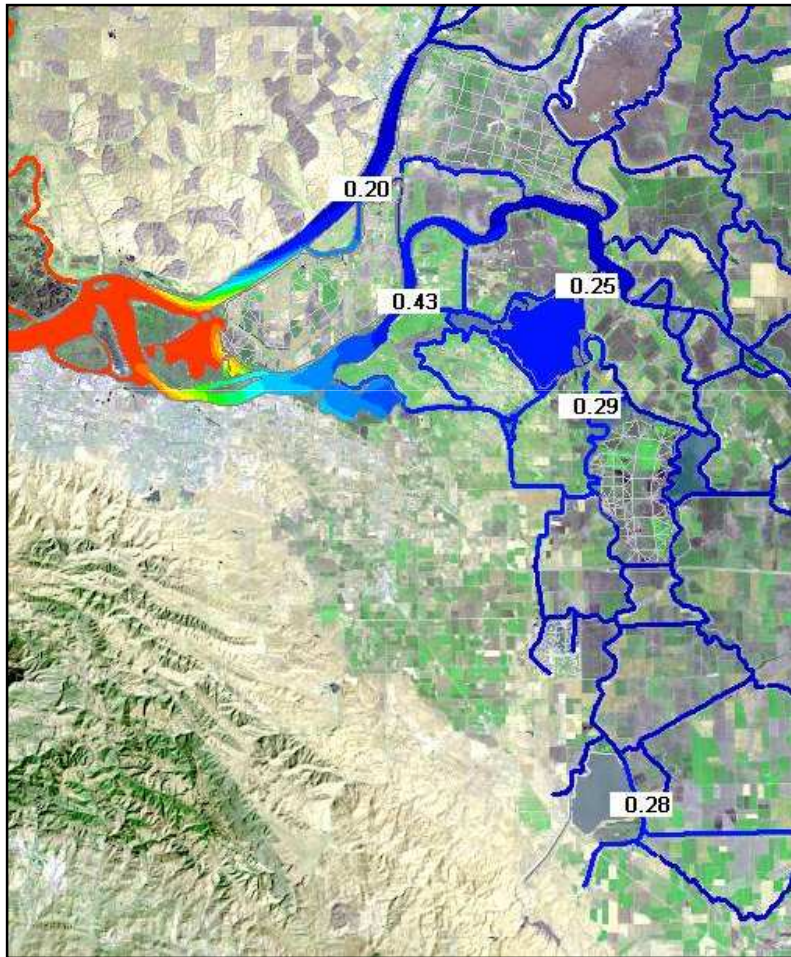


- Highest economic value ecosystem service of the Delta
- 1800 diversions
- 6 MAF/year export



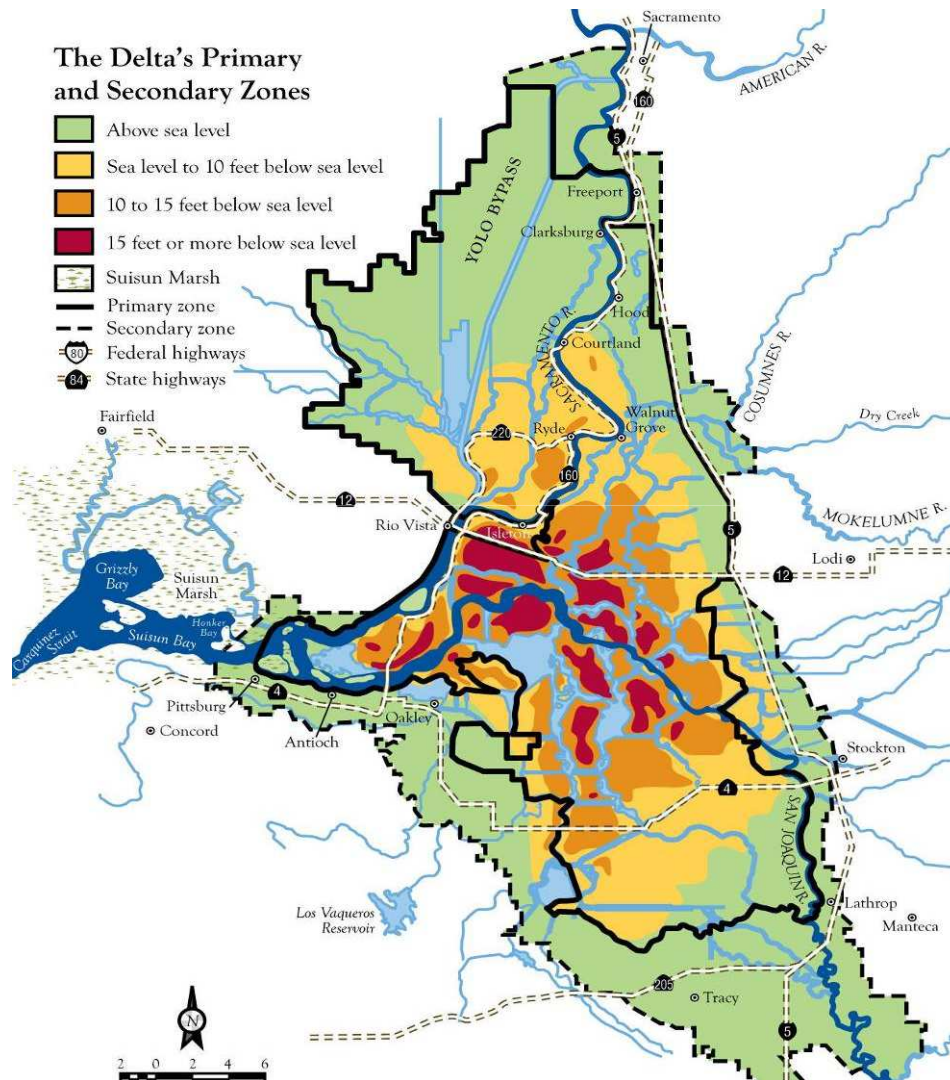


# Keeping the Delta fresh, all the time



A policy since the 1940s to maintain the Delta as an unvarying, freshwater “estuary”, through carriage releases to reduce impacts of tides

# The Late 20<sup>th</sup> Century Sacramento-San Joaquin Delta



- Declining native species diversity and abundance
- Declining water quality and supply reliability
- Increasing flood risk
- Increasing economic and environmental costs

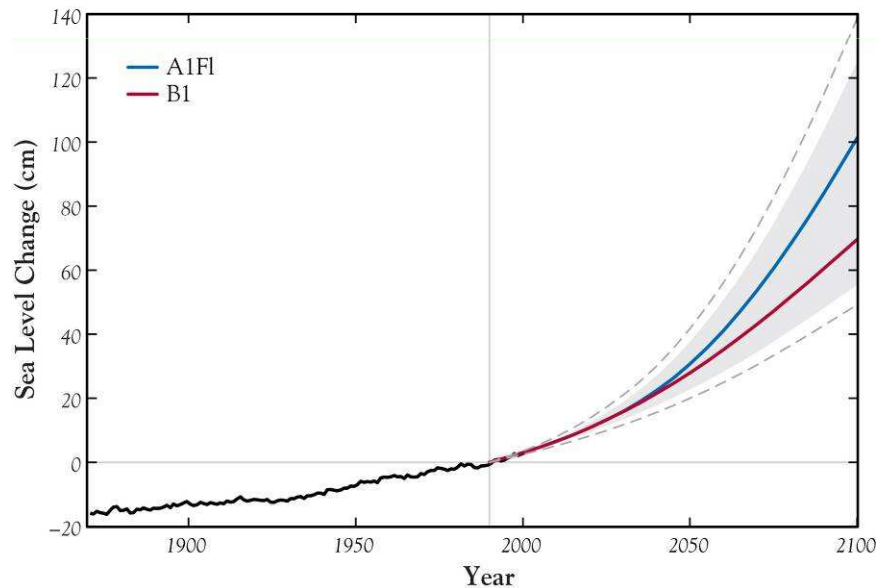
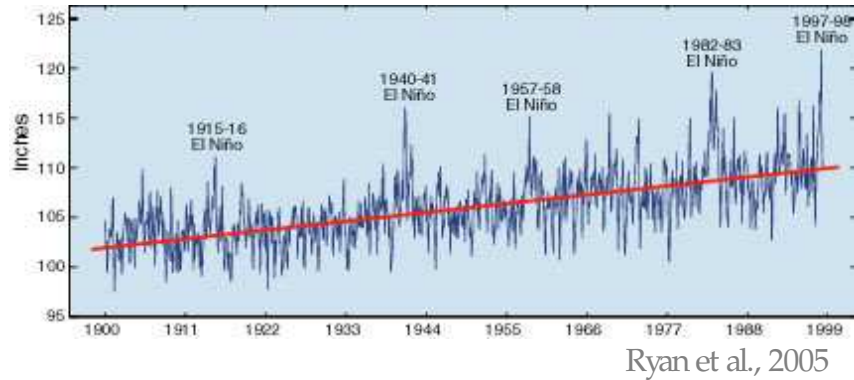


# Transition to the 21<sup>st</sup> Century Delta: Drivers of Change



- Sea Level Rise
- Subsidence
- Changing Inflows
- Seismicity
- Economic
  - Competing Public Interests
  - Limited Public Funds

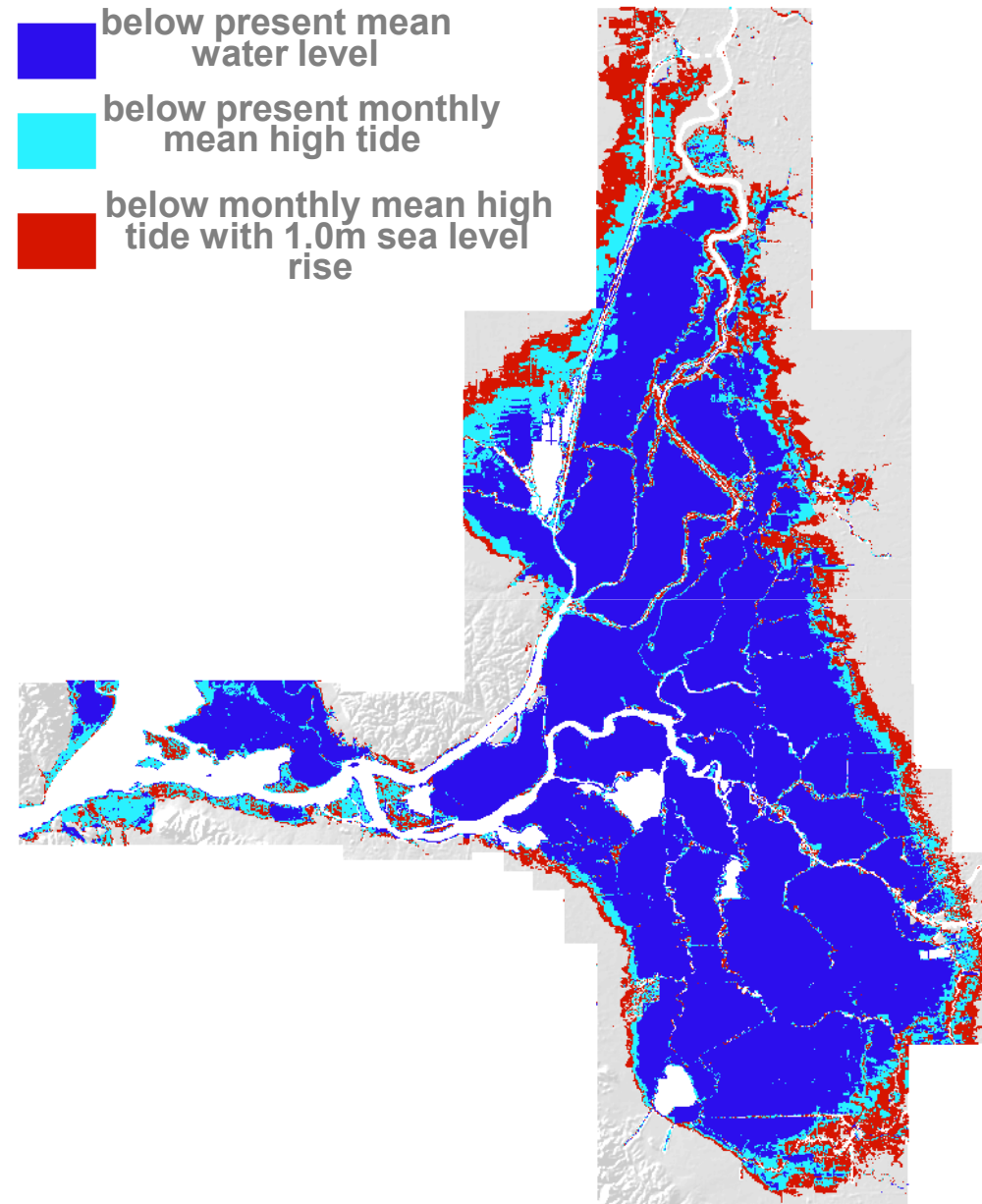
# Sea Level Rise



- Character of Delta based on sea level
- Rate of sea level rise increasing
- Increasing frequency and intensity of extreme high tide events
- A modest rise overwhelms current Delta levee network and increases salinity



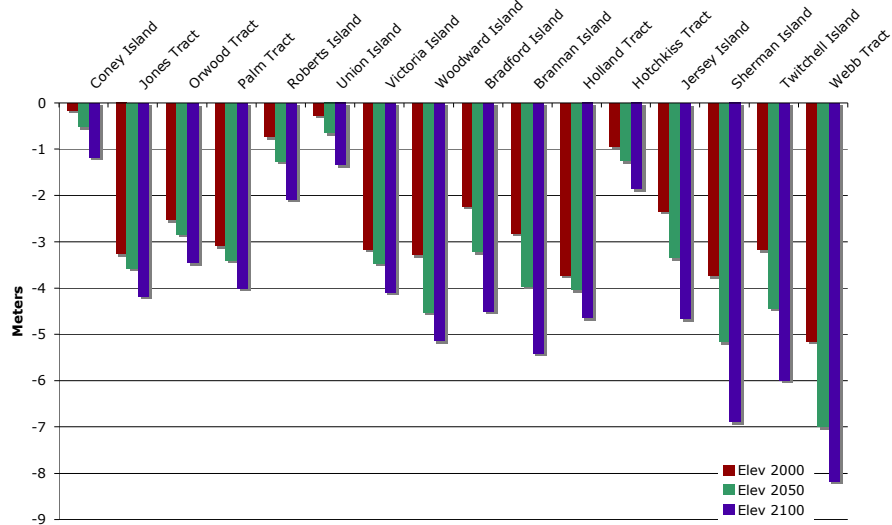
- 1 m sea level rise = 750,000 acres of potential inundation
- Most protected by levees
- Most of Delta is below current and future sea level



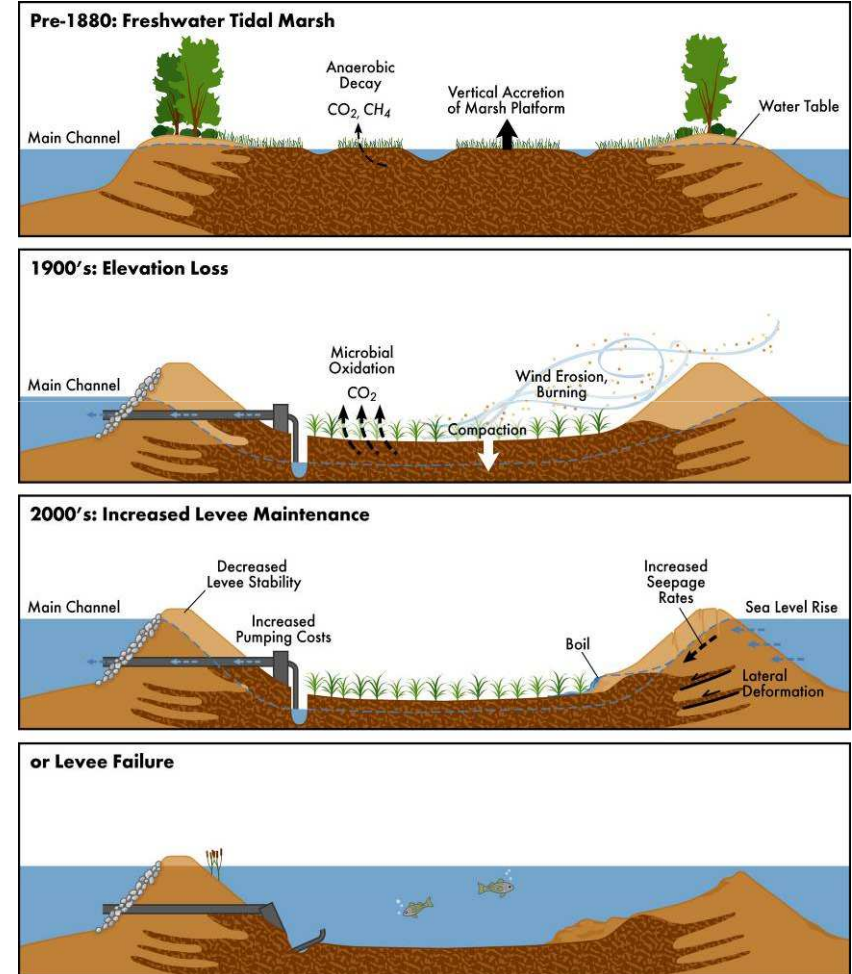
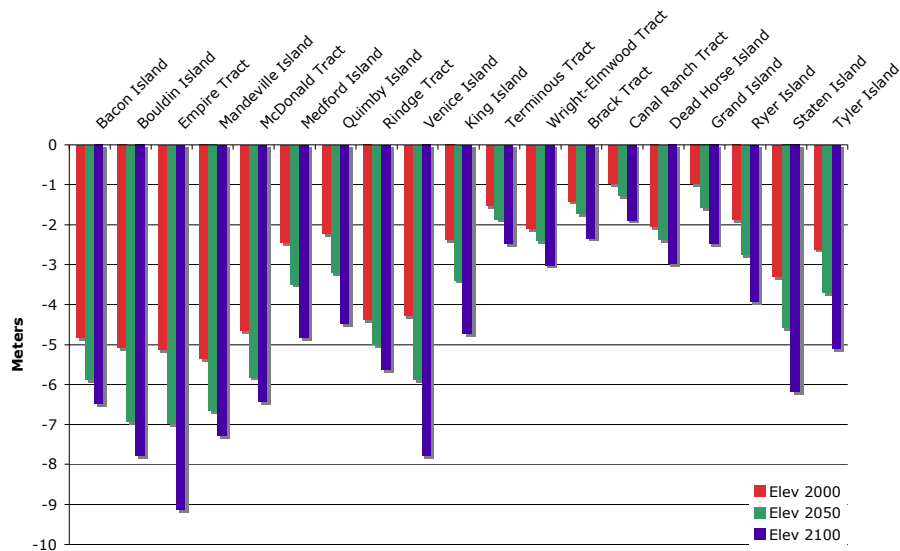
Courtesy: Noah Knowles, USGS

# Subsidence

**Projected Island Elevations due to Subsidence and Sea Level Rise  
Western and Southern Delta**

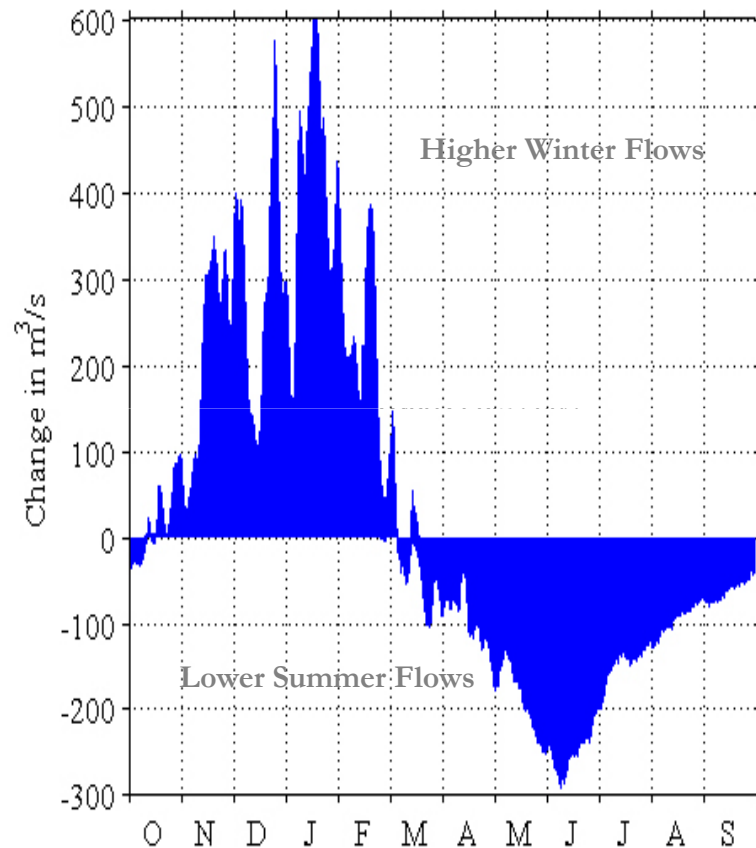


**Projected Island Elevations due to Subsidence and Sea Level Rise  
Northern, Eastern and Central Delta**





# Climate Change: Inflows



Change in inflows to Delta in 2060 (Knowles and Cayan, 2004)

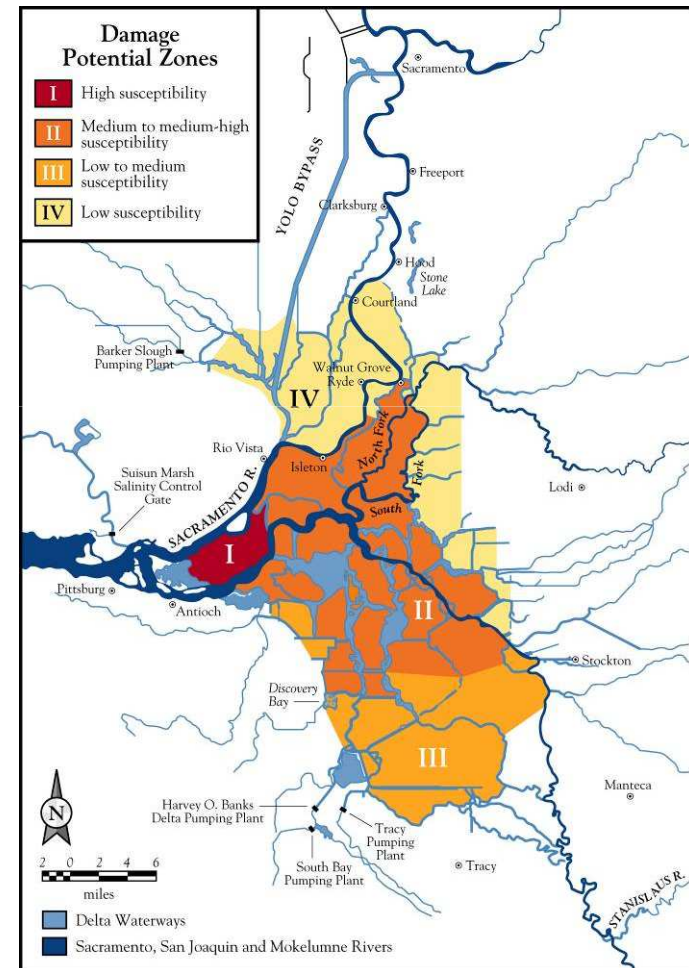
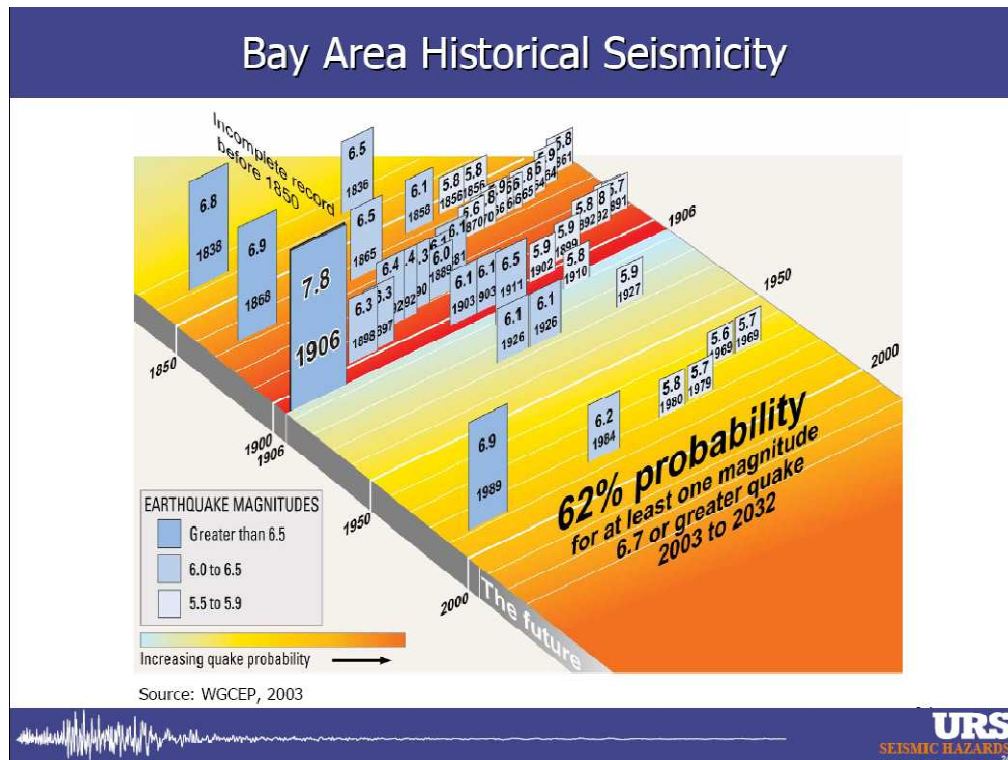
Changing inflows to the Delta associated with changing upstream conditions and operations

Shift in timing of runoff to winter

Increase in frequency and magnitude of flood events

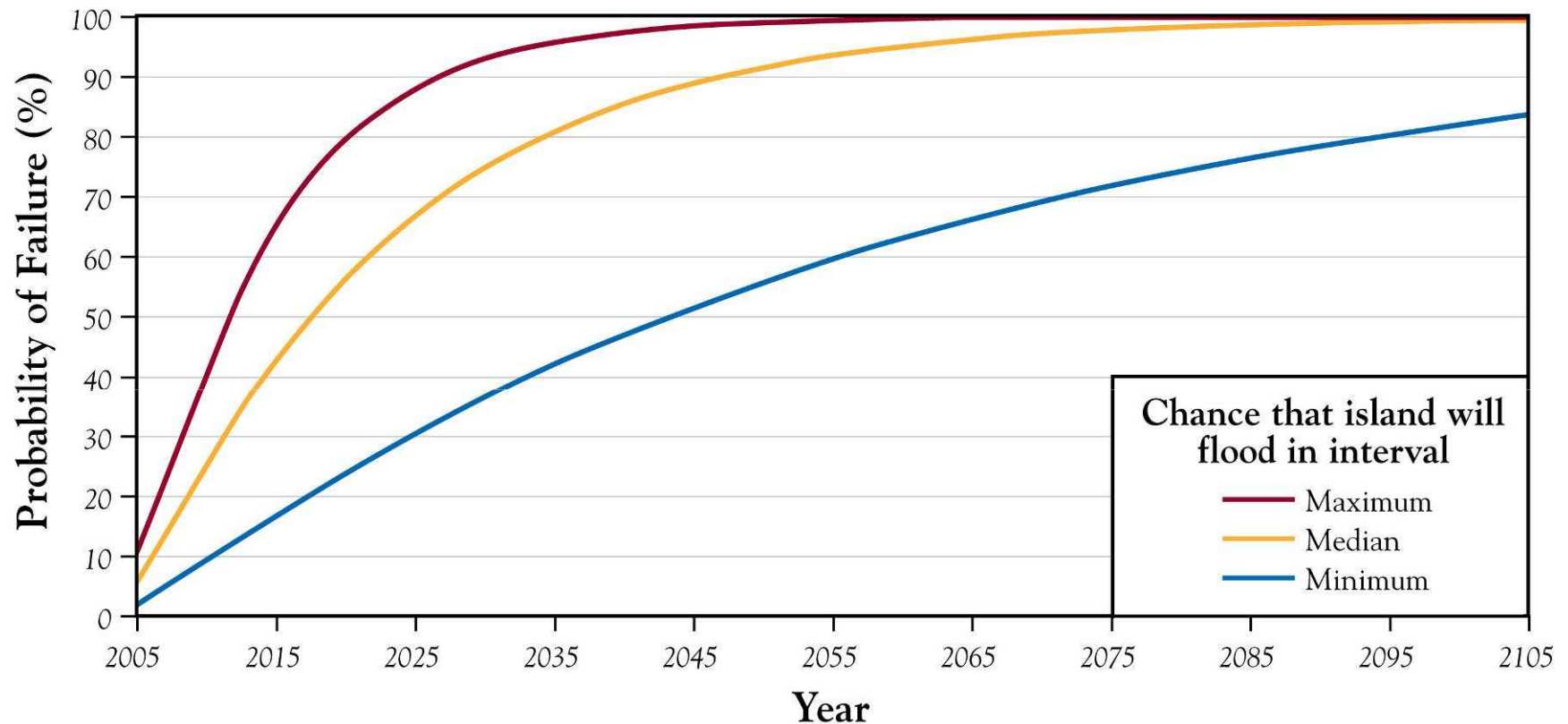
***Historical hydrology not a good predictor of future***

# Increasing likelihood and consequences of levee failure/island flooding



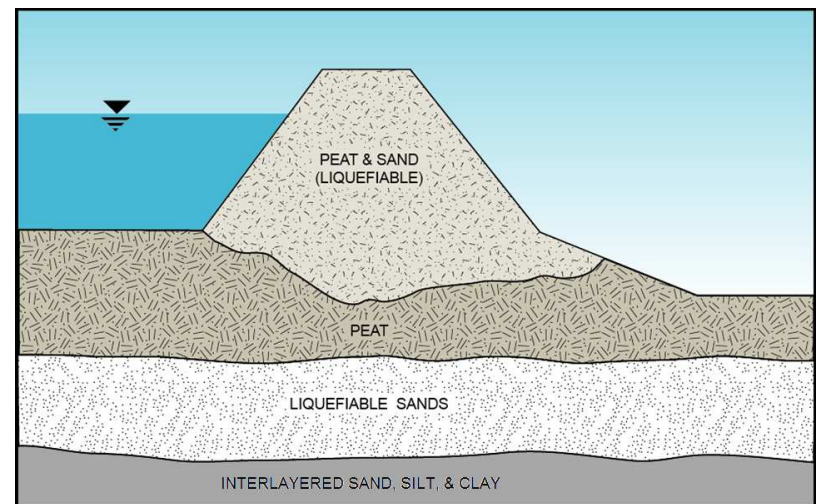


# Flooding Inevitable



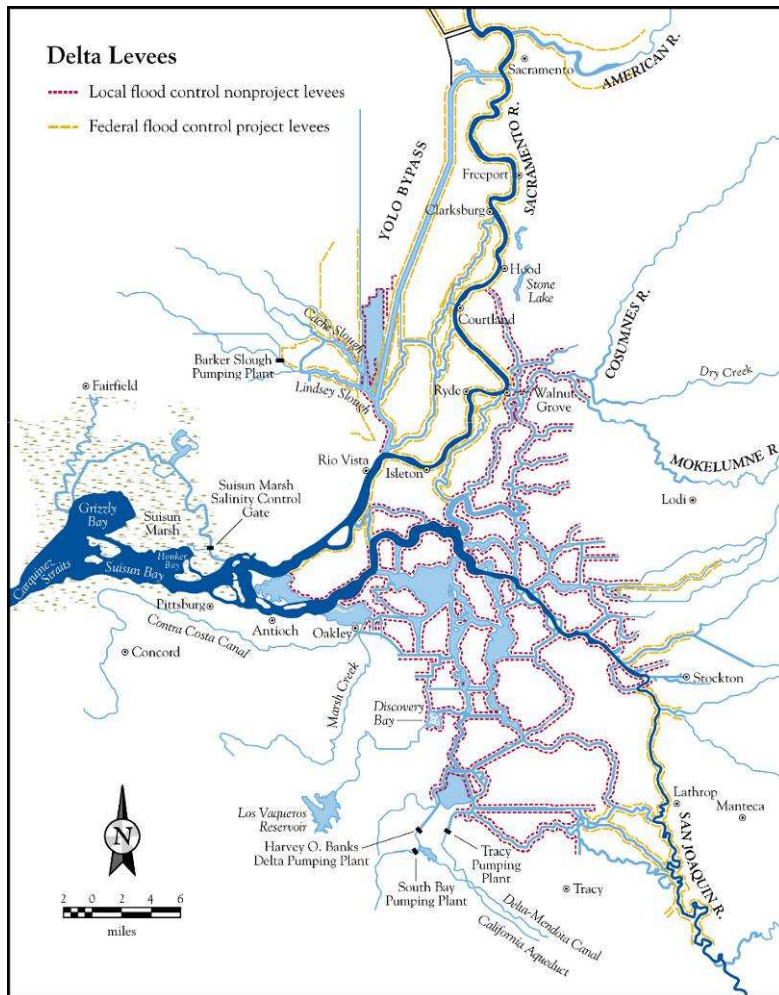
Cumulative probability of levee failure/island flooding due to earthquake OR flood for a given interval of time (based on DRMS draft data)

# Landscape Change will be Driven by Levee Policy



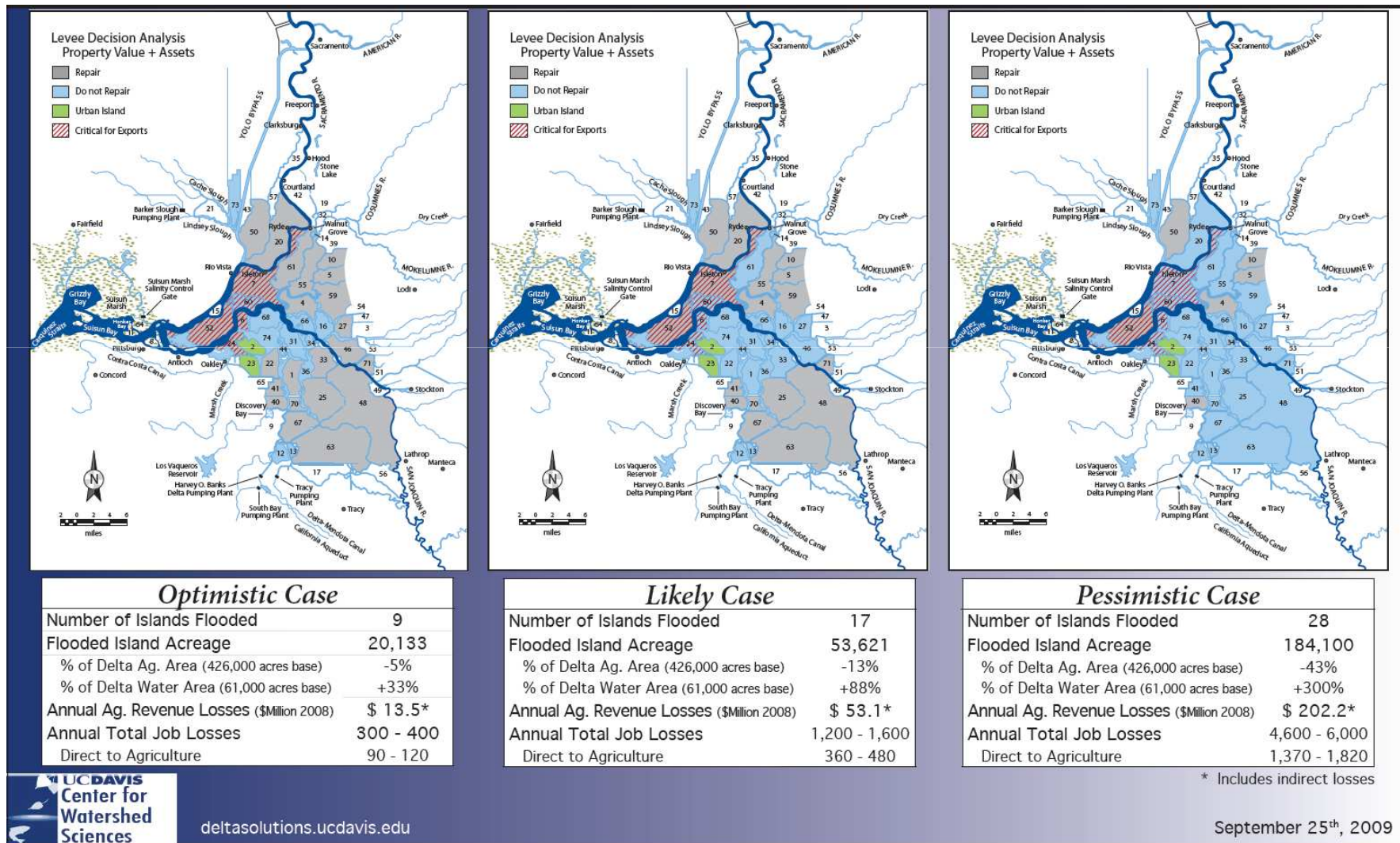



# Economic Drivers of Change



- A measure of resiliency of the Delta is the ability or willingness to repair levees and restore islands
- Evaluated net present value of upgrades and repairs for 34 non-urban islands

# No Upgrades, Repair/Do Not Repair





Ecosystem



Water Supply



Agriculture

# Key Conclusions

- Delta irreversibly changed
- All ecosystem services degraded
- All climate, landscape and ecologic trends negative
- Physical and biological regime change occurring
- *Strategic Decision*: build new facilities or wean off of Delta water supply



19<sup>th</sup> Century Delta



20<sup>th</sup> Century Delta



21<sup>st</sup> Century Delta

“If a man neglect to strengthen his dike and do not strengthen it, and a break be made in his dike and the water carry away the farmland, the man in whose dike the break has been made shall restore the grain which he has damaged.”

-The Code of Hammurabi (circa 2250 BCE), translation by Robert Francis Harper (1904)